bus, subtus pallidioribus; racemis terminalibus simplicibus, 4-9-floris, pedicellis elongatis bibracteolatis, bracteolis linearibus acutis, petiolis pedunculis calycibusque purpurascentibus, corollis aurantiacis, intus versus basin filamentisque villosis, ovario glabro. Species unica :

Campsidium Chilense, Reiss. et Seem. MSS. in Herb. Vindob.; Seem. in Bonplandia, vol. x. p. 147, t. 11.

Tecoma Guarume, Hook. in Bot. Mag. t. 4896, in adnot. (non DeCand.).

Nomen vernaculum Chiloënse "Pilpil Boqui," teste Bridges.

Geographical Distribution. — Chiloë (Bridges! W. Lobb! n. 474, King!); Island of Huafo, lat. 44° S. (Eights! in Herb. Hook.); Arique, near Valdivia (Lechler! Plant. Chil. n. 671).

This beautiful plant seems to be rather common between latitudes 40° and 44° S., and climbs over trees with a height of 40–50 feet. Nevertheless it is not mentioned in Gay's 'Flora of Chile,' and was thought identical with *Tecoma? Guarume* (*Bignonia alata,* Pav.) by Sir William Hooker. The authentic specimens of *Bignonia alata* in the Berlin Herbarium prove, however, to be identical with *Tecomaria fulva,* Seem. (*Tecoma fulva,* DeCand.); and the plant to which Sir W. J. Hooker alludes is the type of an entirely new genus, allied in habit to *Campsis,* Lour., but differing from that genus in the shape of the corolla and parallel, not divaricate, anthers. *Campsidium* has, however, no rooting branches, climber though it be, nor is it winding like *Pandorea,* nor furnished with tendrils like most climbing species peculiar to America.

VI.—*On the Functions of the Nitrogenous Matter of Plants.* By M. L. Garreau *.

The numerous researches prosecuted of late years respecting the organic elements of plants, whilst on the one hand adding to our acquaintance with the structure, composition, and relations of their tissues, have, on the other, suggested to several botanists various theories regarding their evolution and their functions. But the physiology of plants being, like that of animals, inseparably dependent upon the knowledge of their organs, and this knowledge being far from thoroughly understood, the consequence is that every fresh discovery in their organization is followed by a new interpretation of some question or other in their physiological mechanism.

The cell, regarded by most botanists as the primitive element of vegetable organization, is represented as a nearly independent

* Translated by Dr. Arlidge, from the 'Annales des Sciences Naturelles,' tome xiii. 1860, p. 189.

organism, formed by a closed membrane, capable of self-increase, of self-multiplication, and of absorbing and transmitting by endosmosis fluid materials destined to nourish it. This definition, though true in all its details when an examination is conducted by the aid of too feeble or of too strong magnifying powers, or when experiments are conducted on dead tissue, cannot be entirely sustained when the investigation is pursued by appropriate amplifying powers, and when the still living organization is submitted to observation; for, under such circumstances, it becomes possible to demonstrate that the vegetable cell is not so simple in its structure as has been presumed, nor so independent as supposed when it enters into the composition of a tissue. But notwithstanding that the cell is everywhere, whether isolated or aggregated with others, essentially the same in its organization, it is necessary, in order to its minute examination, to employ those portions of plants in which an active process of vegetation is proceeding,—where intra-cellular secretions are absent, and the cellulose and encrusting matters have not as yet so thickened the tissues as to impede the thorough examination of the cell-cavity.

If a slice of vegetable tissue be taken, so thin as to consist of not more than two superposed rows of cells (conditions readily realized in hairs, in the tissue of spongioles, in the lamina of fleshy leaves, in young epidermis, in the pith, in the parenchyma of young petioles, in various fruits, &c.), and if this be examined in a moist state, at a temperature of from 20° to 25° Centigrade, the microscope quickly reveals a small conglomerate mass in each cell, often granular in aspect, and attached to some part of its inner wall. Such is the little body designated by Robert Brown as the *nucleus*, and which he regarded, as did also Schleiden and Hugo Mohl, as a structure existing prior to the formation of the cell-wall. It was moreover looked upon by these naturalists, together with Schultz, Slack, and Meyen, as constituted by the more or less intimate aggregation of nitrogenous granules.

However, this little organ is not entirely formed by the reunion of agglomerated granules, and one might be easily led into error in making researches for its elucidation if it was assumed that it was always to be met with under the aspect above mentioned; for in the majority of the simple hairs of herbaceous plants, in epidermis, and in nearly all young tissues, it occurs under the form of an opaline globule, variable in dimensions, and refracting light much in the same way as fatty matters. Further, under an irregular form, it frequently presents itself in the sub-epidermic cells of leaves, infiltrated with chlorophyl, and with some granules in its middle. Again, in young cells, and in pollen in course of growth, it appears formed of flakes loosely coalesced into irregular spheres; whilst in the cells of young specimens of *Chara*, of *Hydrocharis morsus-ranæ*, of *Stratiotes aloïdes, Caulinia fragilis,* and *Sagittaria sagittifolia,* in the hairs of young shoots of *Borago officinalis,* in the epidermis of the petioles of young specimens of *Arum*, &c., it is represented only by some viscous flakes having no determinate figure. The nucleus, therefore, being essentially a variable organ, has not failed to give birth to the most divergent opinions relative to its nature, origin, and functions; and we should not materially err in asserting that there are not two botanists who entirely concur in respect to its composition or to the part it is intended to play in the economy of the cell. Yet, though this body is susceptible of assuming different aspects, the one under which it usually presents itself is that of a spheroid, in the form of a globule of mucus, having at its centre a collection of semi-transparent granules endowed with sufficient softness to make them adhere feebly together. Now, the presence of this granular matter in the centre is suggestive of the existence of a membranous pellicle about the periphery or surface; and some researches which I have made on this point prove to my mind that this supposition is well founded. Thus, to demonstrate the fact in the epidermis of *Tradescantia virginica*, it is only necessary to treat the slice of tissue under observation with a drop of liquid ammonia, which causes the disappearance of the internal collection of granules, and renders visible a membranous disk, which is no other than the collapsed sac within which the granules were contained. However, this soft pellicle is so very transparent, and of such tenuity, that it is oftentimes very difficult to distinguish its outline with clearness, particularly if, as very often happens, it lies in contact with the wall of the cell.

If, in place of employing the epidermis (which, by the way, need always be very transparent), choice be made of parts richer in water, such as the young root-fibres, the spongioles, the stem of young fleshy plants, the petals, &c., the study of this organ is facilitated; for, under these circumstances, the granular heap is less abundant, and the little membraniform hyaline sac which envelopes it is more perceptible, whilst at the same time the presence of liquid within the sac, apparently of rather stronger refracting-power than the fluid in the cell-cavity, may be detected on submitting the preparation to the action of a dilute acid or of alcohol of 86°; the little sac may be seen to contract and shrivel, to force out a portion of the liquid it contains, and to become reduced to one-third or one-fourth of its original dimensions. If the preparation be now moistened with a little liquid ammonia of 12°, the small sac regains its primitive form, though at the same time it acquires a somewhat larger volume than before, and is less transparent. This change is the consequence either of the action of the reagents upon it, or of the nature of the contained liquid being modified by them. If the flowers of the *Tradescantia virginica* be selected for observation at the moment when they begin to wither, and when the colouring-matter is diffused within the cavities of the cells, the nucleus may be still more precisely studied in respect to its form and its chemical characteristics. The constituent matter of the nucleus being readily penetrated by the colouring-material, and still more strongly impregnated by it than the surrounding cellulose wall of the cell, it happens that, on moistening the preparation with very dilute hydrochloric acid, the nuclear matter acquires an intense red colour, and is thrown into folds, but presently reappears under the eye of the observer with a green tint and of a larger size when the acid reagent is saturated by ammonia or by some other soluble base employed in slight excess. Lastly, on following the appearances along the borders of the film of tissue, and on using slight pressure by the glass covering it, some of these small bodies may be detached and forced out through the ruptured cells, when it becomes evident that they scarcely differ in form or in their nature from mucous globules. It may be added that, if the small body be carefully examined whilst still under the influence of the acid, its centre will be found to be composed of granules strongly condensed into a little mass of a deeper red colour than the softer wall enclosing it, and to which it is fixed by only a single point. From these facts it is at once evident that the nucleus is not a simple collection of particles adhering together, as Brown, Slack, Schultz, and others supposed it to be, but that it possesses a cavity limited by an albuminoid, soft and membranous material, containing granules and a fluid, and that its membrane and granules may be condensed in different degrees by the addition of an acid.

When similar observations are followed out respecting this particular state of the nucleus in tissues whose cells are of sufficient diameter, and their walls transparent enough to permit a just idea of the structure in question to be obtained, then without the help of reagents the above-named facts may be established in the case of most plants, and in all their transparent and actually living parts. But it is a simpler plan, where it is wished only to display the presence of the nucleus, to use a weak solution of iodine in iodide of potassium, which soon tints it of a pale yellow and afterwards of a brown colour. Nevertheless, it is worth noting that this reagent does not act in all plants, or indeed in all parts of a plant, with the same intensity, and that the colour it produces has to be waited for a longer or shorter time, and seems to be influenced by the degree of elaboration of the cellular liquid and by the abundance of nitrogenous granules contained within the membraniform envelope.

Hitherto the nucleus has been referred to as a nearly spherical globule; however, this form is not always that which it presents, although it is the most widely met with when the liquid it contains completely fills it, which happens in those portions of plants which are gorged with a large quantity of water; but when its cavity is less full, or when it is in motion, it has sometimes a wrinkled appearance (as in *Erodium moschatum*), and at others a wrinkled and tuberculated appearance at once (*Salvia Sclarea*), and is very irregular in its outline.

With regard to the dimensions the nucleus may attain, there is great variety; but in general it bears a pretty direct relation to the size of the cells when these have attained their complete growth, or a little before that period. Thus it is that the nucleus is found highly developed in the Liliaceæ, Commelineæ, the Orchidaceæ, Cactaceæ, Crassulaceæ, Aroïdeæ, in most Chenopodieæ and Solaneæ, and in the fleshy parts of all plants, such as the fruit of Rosaceæ, Rhamneæ, Ampelidæ, Grossulariaceæ, &c., which generally exhibit cells of large volume. On the other hand, it is small in most Gramineæ, Apocyneæ, Amentaceæ, and Jasmineæ, whose cells are commonly small in size.

The volume of the nucleus, compared with that of the cell, when young, is proportionally very great, as may be seen in the epidermis of the unexpanded flower of *Helleborus niger*, or in the young merithalli, spongioles, leaves, flowers, and pollen in course of growth; for in such examples the dimensions of the nucleus are so considerable that it sometimes occupies one-fourth of the whole of the cell-cavity. But when the cell has attained its full development, it is adherent to it, and occupies a far smaller proportional space within it than heretofore, being then reduced to one-tenth, one-fifteenth part, or even less of its cavity. However, though the nucleus itself does not keep pace with the growth of the cell, we shall find that, in the subsequent modifications it soon undergoes, it will, by means of appendages given off from it, acquire an equal increase with the cell, and a degree of development proportionate to the extent of its walls.

When examined relative to its consistence, the nucleus is found to be soft and extensible; sometimes, when distended by its contained liquid, it is ruptured in the attempt to detach by a sudden pull the small lamina of tissue to be submitted to examination. Its surface may be smooth, tuberculated, or wrinkled—varieties of appearance of which we shall presently recognize the cause. Lastly, it is not unusual to see it bordered by little vesicles; but these by degrees decrease in size under the eye of the observer, and ultimately merge into it.

The positions it occupies in the cavity of the cell are equally variable; but its most common place is in the centre of the cell, or adherent to some part of its wall. In the latter case, when the cell is elongated, it is seen to be almost always placed equidistant from the two extremities; however, it happens in cells which enter into the structure of hairs, that the nucleus is often seen attached to the septa between them, as in *Tradescantia virginica* and *Chelidonium majus.*

The constancy of this organ in cells in progress of growth led Schleiden to see in it the explanation of an important fact in the physiology of plants; and it was in making an attempt to substantiate this conviction that I was prompted to investigate its different forms, some of its properties, and its relations with the walls of the cell. After having submitted anew to the most attentive and minute observation the majority of the tissues that I had already examined, and which had presented me with cells at once sufficiently developed and transparent, I have been able to satisfy myself that the membranous sac of the nucleus whose characters have been detailed above frequently gives off filaments of the greatest softness, and often anastomosing one with another. Many of their slender extremities likewise proceed to coalesce with the layer of nitrogenous material that lines the interior of the cell-wall. In this structural condition I perceived that I had to deal with an important modification of the nucleus, which, instead of being applied directly to the cell-wall, occupied the centre of its cavity, suspended there by the medium of the viscous processes extended from its periphery as just described. Slack and Meyen long since suspected the relations of these filaments (or, as they called them, currents) with the nucleus. Schultz and Hugo Mohl still more distinctly appreciated this relation; but none of these naturalists would seem to have studied the subject under the most favourable conditions, otherwise they could not have failed to recognize the fact I shall proceed to establish, viz., that these processes are capable in many cells of serving the office of contractile canals for the transmission or circulation of a granular fluid.

On examining, by the aid of a good instrument with a magnifying power of from 300 to 400 diameters, according to the dimensions of the cells, and at a temperature of 25° to 30° Centigrade, a slice of tissue the cells of which presents filamentous nuclei (such as those of the full-grown epidermis of the leaves of the *Tradescantia virginica*, the hairs of *Salvia Sclarea*, of *Chelidonium*, and of *Erodium moschatum*, procured during the summer or autumn), the observer will not fail to recognize the presence of granules streaming in a transparent fluid through a series of canals formed by an extensible membranous matter, continuous with that of the nucleus, though of greater transparency. To view this structure better, the rays of light should fall on the object in a direction parallel to their course, whether it be ordinary daylight or artificial light. It will further appear that the diameter of these canals is often greatly reduced, and that the fluid circulating through them carries along with it only transparent granules of very great tenuity. Now, the existence of such canals within the cell-cavity has always been regarded by the majority of botanists as improbable; and taking this opinion in connexion with the minuteness of the phenomenon itself, it is easily conceivable that the structures just recorded have escaped the researches of micrographers. However, when the investigator has been made acquainted with these phenomena, it is not difficult to demonstrate them, and this even in cells of medium dimensions, provided they are sufficiently transparent and examined with adequate care and patience. To this end, it is enough to moisten the preparation without soaking it with water, to carefully avoid the presence of air which may adhere to the surface, and after covering it with the glass cover, to examine it assiduously and under those conditions with regard to temperature above pointed out. Should the canals not show themselves, gentle compression may be exercised on the preparation, and then the examination be renewed; for by this process the canals are separated and made to stand out from the cell-wall, in the centre of its cavity, where they display themselves and their anastomoses. It is much preferable to make out the existence of these canals without the aid of reagents; but they may be made more evident by the addition of a solution of iodine in iodide of potassium, which gives them a clear yellow or a reddish-brown colour, as it does to the nucleus. But this reagent, though preferable to alcohol or to the aqueous solution of iodine, does not afford a faithful image of the phenomenon, for it slightly contracts the component matter of the canals and deforms it. Besides, before the manifestation of the colour, there is greater or less delay, according to the condition of the fluid in circulation. It is therefore most important, when it is wished to make a critical examination, to abstain from the employment of this reagent, and, indeed, of any other; for, as we shall very soon discover, their vital movements, which such reagents destroy, are the most important of all their properties, and to be studied with the greatest advantage.

The canals existing in a cell derived from elsewhere than the hairs of plants may have various origins; but I shall first point out the characters of such as are in connexion with the nucleus, distinguishing those peculiarities in which they differ from the last-named organ. These canals, being constituted by the membranous matter of the nucleus, arise from the periphery of this organ, and present the greatest variety in size; but from the vital activity in them, and their consequent variability, it is difficult to determine their individual dimensions. Thus, there are some whose diameter is for the moment equal in width to half that of the nucleus, whilst others do not reach the twentieth or thirtieth part of the diameter of that organ. Their number varies equally with their dimensions: at one time a dozen may be seen in the epidermic cells of *Tradescantia virginica*, from six to eight in the epidermis of the flowers of *Lupinus albus*, of *Helleborus niger*, and of *Lilium album*, in the leaves of *Crassula*, in the epidermis and cellular network under the epidermis of the leaves of *Asphodelus luteus*, in the hairs of the young merithalli of *Lamium* and of Geraniums, &c. Lastly, a certain number always escape observation, inasmuch as they cannot be all brought at once within the focus of the lens, and because during the time of examination changes take place among them, both in respect to their relations and dimensions, and create an obstacle to the definite distinction of one from another.

Ordinarily these canals radiate from the nucleus towards the periphery to reach the inner wall of the cell. In this course, some decrease in calibre but slightly, others traverse the distance with uniform width, and almost all frequently anastomose together, either directly or by the medium of lateral offsets they may give off. By this arrangement a network is produced which varies in character in each cell, and is at one time suspended within the cavity of the cell, at another partially attached to the cell-wall. It also happens that at those points where the canals anastomose there is an enlargement, which in its appearance resembles a nucleus additional to the true one, or, in other words, it becomes a centre to and from which a certain number of currents converge or diverge. Before following these canals to their distribution on the cell-walls, we will recall some of their principal physical and chemical characters. They present themselves under the aspect of thin extensile filaments of very great transparency; their component matter has the appearance of a viscid mucus, and seems not to differ, except by its greater consistence, from that which constitutes the small floating flocculi which are observed in circulating or rotatory motion in the young cells of *Nitella flexilis* and of *Chara*, in the cells of the hairs of *Hydrocharis morsus-ranæ*, and in those of the petiole of *Sagittaria sagittifolia*, &c. The observer unskilled in the investigation of these canals experiences some difficulty in discovering them, by reason of their great transparency, and especially when they are sought for in tissues much loaded with water, where their refracting power differs little from that of the surrounding fluid. Alcohol of 86°, by acting upon them, slightly diminishes their transparency, and at the same time contracts them as it does also animal matter. If its application be continued, it is no unusual occurrence to see some of them, that are greatly distended, rupture and collapse, and retreat thereupon towards the nucleus, or, if the rupture takes place near the nucleus itself (which is a rare occurrence), towards the cell-wall.

Hydrochloric acid causes an equal contraction of them, and at the same time diminishes their limpidity. The nitrate of the binoxide of mercury contracts them in the same way, and imparts to them the same rosy hue that it produces with all other albuminoid matters. Liquid ammonia and the other soluble bases, when diluted, produce a contrary effect, causing them to swell up, and tending to dissolve them. From these characters it is evident that in chemical composition these canals resemble albumen, as well as the nucleus itself; indeed, it would be difficult to conceive it to be otherwise, even were no reagents employed.

This might be deemed the proper place to consider the internal causes which incessantly modify the appearance and relations of these canals; however, to avoid repetition, it seems preferable to defer these matters to the second part of this paper.

Hitherto only that portion of the nuclear apparatus which lies freely in the cell-cavity has received attention in the foregoing remarks; we will now proceed to follow its connexion with the cell-walls; and in order more correctly to delineate these relations, it is important to recall some facts concerning the cell-wall itself. As early as the year 1836, M. Girou de Buzareingues had regarded the cell-wall, apart from the thickenings of its external membrane, as composed of two distinct tunics, one within the other. Subsequently Harting investigated this subject, and especially studied the action of some chemical agents on the membrane which circumscribes the cell-cavity, as well as on the other two laminæ which, according to that observer, are deposited on its external surface. From these experiments he satisfied himself, as we moreover had done by our own researches, that the internal membrane, which he named the *ptychode*, behaves with iodine, alcohol, and acids precisely in the same manner as the nucleus. Hugo Mohl also entered on this same inquiry with his customary skill; and his researches went to prove that this internal membrane, which he called "*primordial*," is to be met with in all cells that are not too old or thickened by deposits of encrusting matters. Lastly, Harting, in 1846, showed that the internal membrane adheres only feebly to the external wall of the cell. At the period (1845) when I directed my attention to this internal membranous layer, I was in ignorance of a portion of the labours which had been devoted to it; and it was in the course of my investigation of the nucleus and the intracellular canals that I was led to the discovery of this lamina of the cell in all growing as well as in mature cells when these latter are not too largely coated by encrusting deposits.

This lining-membrane of the cell, being immediately in contact with the external wall, cannot be distinguished whilst preserving its normal relations, and requires the action of reagents to display it. The solution of iodine in iodide of potassium colours it more or less deeply yellow, as it does the nucleus and its processes. In the same manner it is coloured red by the acid nitrate of mercury, and is contracted by the action of acids and of alcohol, indicating in these reactions its similarity in chemical composition to the nucleus and the canals diverging from it. When it has been detached from the external lamina of the cell by means of alcohol, it presents itself under the form of a delicate flexuose sac, of extreme tenuity, and without appreciable structure. However, the same appearances are not met with when the examination is conducted without recourse to reagents, as it may be in the cells of the transparent hairs of *Lamium*, where the lining-membrane undergoes spontaneous detachment at some points of its periphery, if the hairs are allowed to wither a little. In cells so treated, the relations of this inner membrane being only slightly modified, and its vitality not being destroyed, it becomes a more easy task to prosecute its study, and the observer may very soon and easily convince himself that it is hollowed out by minute canals permeating its substance, the most capacious of which outspread themselves upon its internal aspect, whilst the most slender constitute a close network of anastomosing tubercles within its thickness. Nevertheless it is not necessary, in the case of the cells of the plant mentioned, to wait for the partial detachment of this lamina; for the observer, when apprised of the existence of this structure, may satisfy himself of its characters whilst the membrane still retains its normal position.

When the primordial membrane is partially detached from the cell-wall, a very careful examination of the little spaces left between it and the external wall, where the separation is least wide, will reveal the presence of certain very slender filaments implanted in this outer wall; and upon slightly removing this same wall a little out of the focus of the instrument, these filaments may be perceived to form salient lines more illuminated than the rest of the cell-wall—a phenomenon which could not present itself if these filaments were situated in the detached portion of the primordial membrane itself. If I am not in error on this matter, this last fact affords an explanation of the origin of the materials of the cuticle, which, from its composition, can scarcely be derived from the cellulose wall upon which it is placed. However, if this opinion be admissible—and I grant it amounts only to a hypothesis—still there are facts to prove the permeation of the cellulose cell-wall by the tubular processes derived from the nucleus. Moreover, as these processes do form an anastomotic network in the primordial membrane, it seems fair to suppose that portions of them may penetrate to the under surface of the cuticle, or very nearly to it, and that the detachment of the primordial utricle from the cell-wall is the consequence of the rupture of some of the meshes of this network.

It has just been stated that the canals which usually radiate from the nucleus to the cell-wall break up into still smaller channels in the primordial membrane; this, however, is not always the case, for some of them, and often the most capacious, instead of stopping short at this lamina, penetrate it here and there to anastomose with other similar canals emanating from the nuclei of adjoining cells. This fact may be demonstrated by fixing, with great care, a delicate slice of the epidermis of the flower of *Tradescantia virginica* on a glass slide, allowing it to become half dried, so as to secure its adhesion, and then brushing it with a camel-hair pencil dipped in dilute solution of ammonia, which effects the removal of the cuticle. This done, a viscous network is displayed, which establishes a communication between all the cells of the epidermis, and mainly resembles the regular reticulations of some laticiferous vessels. In making these experiments, it frequently happens that a portion of this network gets removed with the cuticle: this circumstance seems to confirm the notion advanced, that the processes of the nucleus are prolonged as far as the cuticle; for if it were otherwise, it is not readily conceivable why these meshes should be removed with it from the soft-walled layer of subjacent cells.

The communication of the processes of adjoining cells through their walls has a physiological importance; for it explains how it is that the animal living matter which composes them is distributed in the different parts of the same plant, and becomes dislodged, as the cells advance in age, in its passage elsewhere, and principally to the periphery, to constitute young cells, where it is known this matter abounds.

[To be continued.]